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| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 09/881,408 | 06/13/2001 | Kie Y. Ahn | MI22-1534 | 8492 |

21567 7590 09/21/2004

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| EXAMINER | |
|---|---|
| LE, THAO X | |

| ART UNIT | PAPER NUMBER |
|---|---|
| 2814 | |

DATE MAILED: 09/21/2004

Please find below and/or attached an Office communication concerning this application or proceeding.

| Office Action Summary | Application No. | Applicant(s) | |
|---|---|---|---|
| | 09/881,408 | AHN ET AL. | |
| | Examiner | Art Unit | |
| | Thao X Le | 2814 | |

*-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --*

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

1)☒ Responsive to communication(s) filed on *14 July 2004*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims**

4)☒ Claim(s) *1-31,52 and 54-62* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☒ Claim(s) *56 and 59* is/are allowed.

6)☒ Claim(s) *1-9,12-27,29-31,52,54,55,57,58 and 60-62* is/are rejected.

7)☒ Claim(s) *10,11 and 28* is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

**Application Papers**

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

**Priority under 35 U.S.C. § 119**

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

**Attachment(s)**

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____.

## DETAILED ACTION

1. The Office Action is in response to RCE filed on 07/14/04.

### *Claim Rejections - 35 USC § 102*

2. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

3. Claims 1-2, 6-9, 12-14, 16-18, 52, 61-62 are rejected under 35 U.S.C. 102(e) as being anticipated by US 6784508 to Tsunashima et al.

Regarding claim 1, Tsushima discloses a method of forming a dielectric layer in fig .2G-3 comprising: a semiconductor substrate 1, fig. 2G, having a silicon-containing surface, forming a first metal-containing dielectric layer 6 consisting of metal oxide, column 5 line 26, over the surface, all the metal of the first dielectric layer consisting of ate least one element selected from Group IVB of the Periodic Table of the Elements, column 5 line 26, and forming a second metal-containing dielectric layer 3 of metal oxide on and in contact with the first metal-containing dielectric layer 6, all the metal of the second dielectric layer 3 consisting of at least one element selected from Group IIIB of the Periodic Table of the Element, column 5 line 35.

Regarding claims 2, 6-7, Tsushima discloses the method wherein the metal of the first metal-containing dielectric layer 6 consists of hafnium, wherein the metal of the second metal-

containing dielectric layer 3 consists of one element selected from Group IIIB of the periodic table, wherein the second metal-containing dielectric layer 3 consists of lanthanum, column 5 line 35.

Regarding claims 8-9, 12, 16-18, Tsushima discloses a method wherein the forming of the first metal-containing dielectric layer 6 and the forming of second metal-containing dielectric layer 3 comprise: forming a hafnium-containing layer; forming a lanthanum-containing layer over the hafnium-containing layer; and exposing the hafnium-containing layer and the lanthanum-containing layer to an oxygen comprising atmosphere and heating the hafnium-containing layer and the lanthanum-containing layer to a temperature effective to form a hafnium-containing dielectric layer and a lanthanum-containing dielectric layer, wherein forming the hafnium-containing layer and the lanthanum-containing layer comprises physical vapor deposition, wherein the exposing comprises positioning the substrate within a reaction chamber and exposing the hafnium-containing layer and the lanthanum-containing layer to oxygen radicals within the reaction chamber, column 6 lines 45-55.

Regarding to claims 13-14, Tsushima discloses the method wherein forming the hafnium-containing dielectric layer 6 comprises depositing hafnium to a thickness less than or equal to about 5 nm; and the forming the lanthanum-containing dielectric layer 3 comprises depositing lanthanum to a thickness less than or equal to about 5 nm, column 5 lines 4-5, wherein a ratio of the hafnium thickness to the lanthanum thickness of from about 1 to 3 to about 1 to 4, column 4-5.

Regarding claim 52, Tsunashima discloses a method of forming a dielectric layer comprising: providing a substrate 1 comprising a silicon-containing surface; forming a first

metal-containing dielectric layer 6 over the surface, the first dielectric layer consisting essentially of hafnium oxide; and forming a second metal-containing dielectric layer 3 on and in contact with the first metal-containing dielectric layer 6, the second dielectric layer consisting essentially of lanthanum oxide, fig. 3.

Regarding claims 61-62, Tsunashima disclose the second dielectric layer 3 consists of lanthanum oxide, column 5 line 35.

4. Claims 1, 52 are rejected under 35 U.S.C. 102(e) as being anticipated by US 6679996 to Yao et al.

Regarding claims 1, 52, Yao discloses a method of forming a dielectric layer in fig. 1A-2C comprising: a semiconductor substrate 1, fig. 1A, having a silicon-containing surface, forming a first metal-containing dielectric layer 3 consisting of metal oxide, column 4 line 22, over the surface, all the metal of the first dielectric layer 3 consisting of at least one element selected from Group IVB of the Periodic Table of the Elements, column 4 line 22, and forming a second metal-containing dielectric layer 3'A of metal oxide on and in contact with the first metal-containing dielectric layer 3'B, all the metal of the second dielectric layer 3'A consisting of at least one element selected from Group IIIB of the Periodic Table of the Element, column 4 line 32.

### *Claim Rejections - 35 USC § 103*

5. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person

having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

6. This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

7. Claim 15, 19-22, 24-25, 54-55, 60 are rejected under 35 U.S.C. 103(a) as being unpatentable over US 6784508 to Tsunashima et al. in view of US 6348373 to Ma et al.

Regarding claim 15, Tsunashima discloses the method wherein forming the hafnium-containing dielectric layer 6 to a thickness than about 1.5 nm, column 5 line 4, the forming lanthanum-containing dielectric layer 3 to a thickness of no greater than about 5 nm, column 5 line 5, wherein a ratio of the first thickness to the second thickness is from about 1 to 3 to about 1 to 4: and the gate dielectric layer has an equivalent oxide thickness of less than or equal to 2 nm, column 5 line 8.

But Tsunashima does not expressly disclose the hafnium-containing dielectric layer 6 having a thickness no greater than about 1.0 nm. Accordingly, it would have been obvious to one of ordinary skill in art to use the hafnium-containing dielectric layer 3 having a thickness than about 1.5 nm teaching of Tsunashima in the range as claimed, because it has been held that where the general conditions of the claims are discloses in

the prior art, it is not inventive to discover the optimum or workable range by routine experimentation. See In re Aller, 220 F.2d 454, 105 USPQ 233, 235 (CCPA 1955).

Regarding claims 19, 60 Tsunashima discloses the method wherein the first dielectric layer 6 consisting of hafnium silicate, column 5 line 27, and a second dielectric layer 3 consisting of lanthanum oxide, column 5 line 35.

But Tsunashima does not expressly disclose the first dielectric layer 6 consisting of hafnium oxide.

However, Ma reference discloses the method comprises a gate dielectric layer 20 (120), fig. 3, can be hafnium oxide or hafnium silicate, column 3 lines 4-6. At the time of the invention was made; it would have been obvious to one of ordinary skill in the art to replace the hafnium silicate layer 6 of Tsunashima with hafnium oxide layer 120 teaching of Ma, because such material replacement would have been considered a mere substitution of art-recognized equivalent values.

Regarding claims 20, 54-55 as discussed in the above claim 1 and 19, the combination Tsunashima and Ma discloses all the limitation of claims 20, 54.

Regarding claims 21-22, 24-25, Tsushima discloses the method wherein the forming the hafnium-containing metal layer 6 and the forming the lanthanum-containing metal layer both comprise physical vapor deposition, where physical vapor deposition comprises electron beam evaporation, wherein the forming the hafnium-containing dielectric layer 6and the forming the lanthanum-containing dielectric layer 3 further comprise exposing the hafnium- and lanthanum-containing metal layers to an oxygen comprising atmosphere while heating the metal layers to a temperature effective to form a hafnium-containing dielectric layer and a lanthanum-containing

dielectric layer, where forming the hafnium-containing dielectric layer 6 and the lanthanum-containing dielectric layer comprise forming oxides of hafnium and lanthanum, respectively, column 6 lines 45-55.

8. Claims 3-5, 23, 26-27, 29-31, 58 are rejected under 35 U.S.C. 103(a) as being unpatentable over US 6784508 to Tsunashima et al. and US 6348373 to Ma et al as applied to claim 20 above and further in view of US 6184072 to Kaushik et al.

Regarding claims 3, 5, 23, 26-27, Tsunashima discloses a method of forming a dielectric layer comprising: providing a substrate 1 comprising a silicon-containing surface; forming a metal layer 6 over the substrate heating the metal layer to a temperature of from about 800°C, column 6 line 51, to form a metal oxide dielectric material comprised by a first metal-containing dielectric layer 6 over the surface, all the metal of the first dielectric layer consisting of at least one element selected from Group IVB of the periodic table, and forming a second metal-containing dielectric layer 3 on and in contact with the first metal-containing dielectric layer 6, all the metal of the second dielectric layer consisting of at least one element selected from Group IIIB of the periodic table.

But Tsunashima does not disclose forming a silicon dioxide layer over a portion of the surface comprising silicon, prior to forming of the hafnium-containing dielectric layer, wherein the heating comprises heating the hafnium- and lanthanum-containing metal layers to a temperature from about 200°C to about 400°C, and further comprising providing conditions effective for the hafnium-containing metal layer to chemically reduce the layer of silicon dioxide.

However, Tsunashima discloses the heating about 800°C, column 6 line 51. And Kaushik reference discloses forming a silicon dioxide layer 14, fig. 1, column 2 line 60, hafnium metal layer 16, fig. 2 over a portion of the surface comprising silicon, prior to forming of the hafnium-containing dielectric layer 14, fig. 3, and heating about $400^0$C to $800^0$C, column 3 line 20, and further comprising providing conditions effective for the hafnium-containing metal layer to chemically reduce the layer of silicon dioxide, fig. 3 column 3 lines 13-30. At the time the invention was made; it would have been obvious to one of ordinary skill in the art to combine the teaching of Kaushik's method with Tsunahima's method, because it would have created a high k gate dielectric layer as taught by Kaushik, column 2 line 3-7. With respect to heating temperature, it would have been obvious to one of ordinary skill in art to use the heating temperature teaching of Tsunashima and Kaushik in the range as claimed, because it has been held that where the general conditions of the claims are discloses in the prior art, it is not inventive to discover the optimum or workable range by routine experimentation. See In re Aller, 220 F.2d 454, 105 USPQ 233, 235 (CCPA 1955).

Regarding claim 4, Tsunashima discloses the metal layer 6 comprises hafnium.

Regarding to claim 29, Tsushima discloses the method wherein forming the hafnium-containing dielectric layer 6 comprises depositing hafnium to a thickness less than or equal to about 5 nm; and the forming the lanthanum-containing dielectric layer 3 comprises depositing lanthanum to a thickness less than or equal to about 5 nm, column 5 lines 4-5, wherein a ratio of the hafnium thickness to the lanthanum thickness of from about 1 to 4 to about 4 to 1, and no greater than about 6 nm, respectively, column 4-5.

Regarding claims 30-31,Tsunashima discloses the method wherein the thickness of the hafnium-containing metal layer 6 is about 1.5 nm, column 5 line 4, wherein the hafnium-containing dielectric layer 6 and the lanthanum-containing dielectric layer 3 are collectively a gate dielectric layer, where the gate dielectric layer is formed having an equivalent oxide thickness less than or equal to 2 nm, column 5 line 8.

With respect to the thickness of hafnium-containing metal layer 6, it would have been obvious to one of ordinary skill in art to use the thickness teaching of Tsunashima in the range as claimed, because it has been held that where the general conditions of the claims are discloses in the prior art, it is not inventive to discover the optimum or workable range by routine experimentation. See In re Aller, 220 F.2d 454, 105 USPQ 233, 235 (CCPA 1955).

Regarding claim 58, Tsunashima discloses a method of forming a dielectric layer comprising: providing a substrate 1 comprising a silicon-containing surface, forming a hafnium-containing layer 6 over the substrate; forming a lanthanum-containing layer 3 over the hafnium-containing layer 6; and positioning the substrate within a reaction chamber and exposing the hafnium-containing layer and the lanthanum-containing layer to oxygen radicals within the reaction chamber and heating the hafnium-containing layer and the lanthanum-containing layer to a temperature effective to form a hafnium-containing dielectric layer and a lanthanum-containing dielectric layer, column 6 lines 45-55.

But, Tsunashima does not discloses forming a layer of silicon dioxide overlying at least one portion of the surface and combing hafnium of the hafnium-containing layer with oxygen of the silicon dioxide layer to form a hafnium oxide over the surface.

However, Kaushik reference discloses forming a silicon dioxide layer 14, fig. 1, column 2 line 60, overlying at least on portion of the surface, a hafnium metal layer 16, fig. 2 over a portion of the surface comprising silicon, and combining hafnium of the hafnium-containing layer with oxygen of the silicon dioxide layer to form a hafnium oxide 18, column 3 line 27, over the surface. At the time the invention was made; it would have been obvious to one of ordinary skill in the art to combine the teaching of Kaushik's method with Tsunahima's method, because it would have created a high k gate dielectric layer as taught by Kaushik, column 2 line 3-7.

9. Claims 20, 54-55 are rejected under 35 U.S.C. 103(a) as being unpatentable over US 6679996 to Yao et al.

Regarding to claims 20, 54-55, Yao discloses a method for forming a MOS transistor, column 12 line 9-20, comprising: a semiconductor substrate 1, fig. 2C, having a surface comprising silicon, column 3 line 57, forming a hafnium-containing dielectric layer 3'B consisting of hafnium oxide, column 4 line 22, on and contacting the surface 1, forming a lanthanum-containing layer 3'A, fig. 2C, on and in contact with the hafnium-containing dielectric layer 3'B,such forming comprising initially forming a lanthanum-containing metal layer.

But, Yao does not disclose a gate electrode overlying the gate dielectric layer. However, Yao discloses the metal oxide layer can be used in different IC device among others including transistor or DRAM, FeRAM, column 12 lines 9-25. At the time the invention was made; it would have been obvious to one of ordinary skill in the art to use the teaching of Yao to dispose a gate electrode overlying the gate dielectric layer

3'A/3'B, because such gate electrode is conventional in the art, see Tsunashima or Ma references above.

### *Allowable Subject Matter*

10. Claims 10-11, 28 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims. The prior art of record neither anticipated not rendered obvious the limitation 'where the exposing comprises ion bombardment of the first hafnium-containing layer and the lanthanum-containing layer using an ion bombardment energy of about 10 electron volts (eV0 or less' of claims 10 and 28.

11. Claims 56-57, 59 are allowed because the prior art of record neither anticipated not rendered obvious the limitation 'where the exposing comprises ion bombardment of the first hafnium-containing layer and the lanthanum-containing layer using an ion bombardment energy of about 10 electron volts (eV) or less' of claim 56 and 59.

12.

### *Conclusion*

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Thao X Le whose telephone number is (571) 272-1708. The examiner can normally be reached on M-F from 8:00 AM - 4:30 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Wael M Fahmy can be reached on (571) 272 -1705. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

Thao X. le
13 Sept. 2004

LONG PHAM
PRIMARY EXAMINER